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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>5</sup> : <b>A61M 29/00</b>		<b>A1</b>	(11) International Publication Number: <b>WO 94/11051</b>
			(43) International Publication Date: <b>26 May 1994 (26.05.94)</b>
<p>(21) International Application Number: <b>PCT/US93/00882</b></p> <p>(22) International Filing Date: <b>3 February 1993 (03.02.93)</b></p> <p>(30) Priority data: 07/978,230                      19 November 1992 (19.11.92)    <b>US</b></p> <p>(71) Applicant: <b>TARGET THERAPEUTICS, INC. [US/US];</b> 47201 Lakeview Boulevard, P.O. Box 5120, Fremont, CA 94537-5120 (US).</p> <p>(72) Inventors: <b>CHEE, U., Hiram ; 4151-D El Camino Way, Pa-</b> <b>lo Alto, CA 94306 (US). MARIANT, Mike ; 2169 Ventu-</b> <b>ra Place, Santa Clara, CA 95051 (US). ENGELSON,</b> <b>Erik, T. ; 556 Bush Street, Mountain View, CA 94041</b> <b>(US).</b></p>		<p>(74) Agents: <b>CAGAN, Felissa, H. et al. ; Morrison &amp; Foerster,</b> 755 Page Mill Road, Palo Alto, CA 94304-1018 (US).</p> <p>(81) Designated States: <b>AU, CA, FI, HU, JP, KR, NO, NZ, PT,</b> European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> <i>With international search report.</i></p>	
<p>(54) Title: <b>LARGE DIAMETER VASOOCCLUSION COIL</b></p>			
			
<p>(57) Abstract</p> <p>A device for occluding a large diameter (1 to 3 cm) vessel. The device comprises a helical coil (10) having a multiplicity of windings (14). The helical coil (10) may further be shaped into a variety of structures including a C-shape, a cloverleaf, and a figure 8.</p>			

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5                    LARGE DIAMETER VASOOCCLUSION COILDescriptionTechnical Field

10                    This invention is in the general field of surgical instruments. More particularly, it relates to a vasoocclusion device that can be used in cardiovascular and endovascular procedures.

15                    Background

                    Vasoocclusion devices are surgical implements that are placed within vessels, typically via a catheter, to block the flow of blood through the vessel. Vasoocclusive coils have been used to occlude vessels in  
20                    small-diameter, difficult to reach sites. United States Patent No. 4,994,069 provides a vasoocclusive wire that is guided to a vessel that has a diameter of between 0.5 and 6 mm. The patent describes a flexible vasoocclusive wire that is designed to occlude a vessel when the wire  
25                    is released into the vessel. The diameter of the coiled wire is between about 10-30 mils, the wire itself has an outside diameter of between about 2-6 mils and there are about 4-8 helical windings. For vasoocclusion of a vessel that is 0.5-2 mm, the wire has a preferred length  
30                    of about 3-6 cm, and for a vessel that is 2-6 mm, the wire has a preferred length of about 5-10 cm.

                    The above described coils, therefore, are effective to occlude vessels of between about 0.5 and 6 mm which require tortuous path access. Where, however,  
35                    the vessel is between about 1-3 cm, the coils were

thought to be impractical as they would be too long to be reliable and might occlude neighboring vessels.

#### Disclosure of the Invention

5           It is therefore an object of the present invention to provide a vasoocclusive device that can be used to occlude large diameter vessels. The device is a vasoocclusive coil that assumes a linear helical configuration when stretched and a folded convoluted  
10 configuration when relaxed. The stretched condition is used in placing the coil at the desired site and the coil assumes its relaxed configuration once the device is so placed.

          The vasoocclusive device is a helical coil  
15 having a multiplicity of windings between a first and second end wherein the primary coil diameter is between about 0.25 and 1.5 mm and the diameter of the vessel to be occluded is between about 1.0 and 3.0 cm. Once relaxed, the coil may assume a secondary coil diameter  
20 approaching that of the selected vessel.

#### Brief Description of the Drawings

          Figs. 1 to 9 are fragmentary elevational views (not to scale) of embodiments of the helical coil of the  
25 invention.

          In the drawings, like structures are referred to by the same reference numeral.

#### Modes for Carrying Out the Invention

30           Fig. 1 depicts one embodiment, generally designated 10, of the helical vasoocclusive coil of the invention. The helical coil 10 will typically be made of a radiopaque material such as platinum, tungsten, gold, stainless steel, or of alloys such as tungsten and  
35 platinum. A tungsten-platinum alloy is preferred because

of its strength and toughness. The material desirably is radiopaque and the diameter of the wire will usually be in the range of 0.05 to 0.25 mm. The coil has a multiplicity of individual windings 12. The axial length of the coil will usually be in the range of 0.2 to 100 cm, more usually 0.2 to 40 cm and the diameter of the coil will normally be 0.25 and 1.5 mm, more usually 0.5 to 1.0 mm. The coil will typically have about 40 to 200 windings per cm, more typically about 50 to 130 windings per cm.

The steps in the construction of the vasoocclusion coils of this invention are shown in Figs. 1-3. The coil itself may be formed by wrappings of windings of a fine radiopaque wire thread, preferably 5 to 8 mil (0.13 to 0.20 mm) platinum, tungsten, gold, stainless steel or alloy thread which is available, for example, from California Fine Wire Company (Grover City, CA). The windings are preferably made by wrapping the thread on a spinning mandrel, according to known coil-manufacturing methods. The wire advance on the mandrel is adjusted to produce a single-layer coil with a minimum helical pitch, i.e., in which the windings are closely packed. Typically, the mandrel has a diameter of between about 0.10 and 1.0 mm yielding a coil whose outer diameter is between about 0.25 and 1.5 mm. The soft, flexible coil produced on the mandrel is cut to a desired length of between about 4 and 100 cm after removal from the mandrel.

The coiled wire may then be wound on a larger diameter mandrel to form a helical winding as shown in Fig. 2 whose helix diameter, indicated at 14, is approximately that of the vessel for which the coil is intended. The helical axis is indicated at 16. Thus for a wire designed for vasoocclusion of a vessel of about 1-3 cm, the diameter of this secondary helical winding is

preferably 1-3 cm, respectively. It can be appreciated from the above-mentioned wire lengths and winding diameters, that the wires typically will contain 1-20 helical windings, more typically 4-8 helical windings as  
5 illustrated in Fig. 2.

The coil may further be preformed to contain irregularities in the helical winding, such that the coil adopts a folded, convoluted conformation in a relaxed condition as illustrated in Fig. 3. As seen, the  
10 irregularities in this embodiment are such as to offset the helical axis (indicated by arrows in the figure) of each winding by 20-40 degrees. The irregularities are preferably made by deforming, as by twisting, the coil in the region of desired bends with the coil on the helical  
15 winding mandrel. The coil may be treated by heating at about 800°F for about 24 hours for memory retention after it is shaped.

According to an important feature of the invention, the combination of the helical winding and the  
20 irregularities in the winding cause the coil to form a randomly shaped, substantially space-filling mass when released into a vessel, as will be illustrated below. In particular, the memory in the coil is effective to return the coil from a stretched, linear condition in which it  
25 is advanced through a catheter to a randomly oriented, space-filling relaxed condition as the coil is released from the catheter.

The coil just described may be thought of as having a primary structure formed by the wire wrapping  
30 making up the coil, a secondary structure formed by the helical winding of the coil, and a tertiary structure formed by the irregularities in the winding of the coil. It will be appreciated that the random shape of the coil in its relaxed condition can be achieved by other,  
35 related secondary structures in the coil, such as a

series of arcs which are interrupted at intervals by bends which orient the arcs in different directions.

In an alternative method of manufacture, the primary helical coil may be wound around a series of  
5 mandrels that are held in some uniform configuration to yield the offset helical shape shown in Fig. 3. Multiple coils may be formed in this way and thereafter the coils may be cut to form individual vasoocclusive coils.

The coil is preferably supplied in prepackaged  
10 form in a sterile cannula. The cannula straightens the coil during shipment such that it can be placed within a catheter lumen for delivery to the targeted vessel.

A guidewire is inserted such that a catheter can be guided to the targeted vessel. Once the catheter  
15 is in place within a vessel, the guidewire is removed and the coil-containing cannula is placed into engagement with the proximal end of the catheter. The coil is then transferred from the cannula lumen into the catheter lumen by exerting force on the proximal end of the coil.  
20 The coil is advanced through the catheter to the tissue of interest by means a guidewire or coil pusher that pushes against the proximal end of the coil. Alternatively, water may be injected into the catheter to force the coil through the catheter lumen. The location  
25 of the coil may be visualized due to the radiopacity of the helical coil. Once at the site, the coil is plunged from the distal end of the catheter into the targeted vessel.

In an alternative method in which the guidewire  
30 remains in place during coil ejection, the coil is supplied in a cannula which is adapted to engage the proximal end of a guidewire. Once the guidewire and catheter are in place, the coil-containing cannula is placed into engagement with the proximal end of the  
35 guidewire and the coil is transferred from the cannula



lumen onto the guidewire by exerting force on the proximal end of the coil. The coil is delivered to the targeted site by being pushed with a guidewire, coil pusher or by means of hydraulic injection as described  
5 above.

Figs. 1 to 9 show variants of the invention, but for simplicity of explanation, show the shape when the coil is in the catheter lumen (Figs. 1 and 7) and after release of the coil at the targeted site (Figs. 2  
10 to 6, 8 and 9).

Fig. 2 shows a partial side view of the helical coil 10 in its relaxed configuration. Typically the coil 10 will be placed inside the catheter lumen in its linear stretched form (as shown in Fig. 1) until discharged from  
15 the end of the catheter at which time the configuration shown in Fig. 2 will be assumed.

Fig. 3 shows another embodiment of a vasoocclusive coil of the invention after it has been released from the end of the catheter. The coil loops  
20 back upon itself to form a secondary coil having a tertiary configuration that may substantially fill the vessel to be occluded. Irregularities in the coil windings allow formation of the folded convoluted conformation in the coil's relaxed condition. As seen,  
25 the multiple convolutions or irregularities in the embodiment are such as to offset the helical axis (the arrows in Fig. 3) of each winding by 20-40 degrees.

Figs. 4, 5, and 6 each illustrate a different aspect of the invention. Whereas Fig. 3 shows a helical coil that forms a tertiary shape that is circular, Figs.  
30 4-6 show additional coils whose tertiary structures are also useful in the invention. Fig. 4 shows a cloverleaf-shaped vasoocclusive coil, Fig. 5 shows a figure-8-shaped and Fig. 6 shows a C-shaped vasoocclusive coil. The  
35 tertiary structures are the relaxed configurations of the

coils after release into the vessel. The devices are introduced as helical coils as shown in Fig. 1 and then assume the shapes shown. The maximum helical coil diameters of the coils shown as 20, 22 and 24 are  
5 equivalent to the size of the vessel to be occluded, that is 1-3 cm.

Figures 7 and 8 show a vasoocclusive coil such as is described above, but in which irregularities in the helical winding are produced by flattening the wire coil  
10 in different directions. This may be accomplished by flattening or squeezing the linear coil 30 in a number of places 32 along the winding at various angles (if so desired) such as is shown in Fig. 7. The coil so formed will have the general appearance shown in Fig. 7 when in  
15 its linear configuration. The coil will be in its linear configuration as shown in Fig. 7 during its introduction into the vessel, but will assume the shape shown in Fig. 8 when in its relaxed configuration.

Fig. 9 shows a coil having a primary coil  
20 structure as described above, with a helical winding 40 having at least one helical turn whose diameter 42 is the size of the vessel to be occluded. In this variation, the irregularities in the helical winding take the form of continually changing helical diameters forming spirals  
25 which are dimensioned to span the cross-sectional area of the vessel.

The coils of the present invention, therefore are useful for occluding vessels in the range of about 1 to 3 cm. Such applications include the occlusion of  
30 fistulas of the pulmonary vasculature in the lungs, trauma in the periphery, arteriovenous malformations, heart anomalies and aneurysms.

Modifications of the above-described modes for carrying out the invention that are obvious to those of  
35 skill in the fields of medical device design generally,

and vasoocclusion specifically are intended to be within the scope of the following claims.

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Claims

1. A vasoocclusive device comprising a primary helical coil having a multiplicity of windings between a first and second end, wherein the diameter of  
5 the primary helical coil is between about 0.25 and 1.5 mm and the diameter of the vessel to be occluded is between about 1.0 and 3.0 cm.
2. The vasoocclusive device of claim 1  
10 wherein the helical coil is from about 0.2 to 100 cm in length and has about 40-200 windings per cm.
3. The device of claim 1 wherein the helical coil assumes a secondary helical coil-shaped structure  
15 with between about 4-8 windings.
4. The device of claim 3 wherein the diameter of the secondary helical coil-shaped structure is between about 1.0 and 3.0 cm.  
20
5. The device of claim 3 wherein the helical coil assumes a tertiary structure formed by irregularities in the windings of the secondary helical coil-shaped structure.  
25
6. The device of claim 1 wherein the helical coil assumes a secondary cloverleaf-shaped structure.
7. The device of claim 1 wherein the helical  
30 coil assumes a secondary figure 8-shaped structure.
8. The device of claim 1 wherein the helical coil assumes a secondary C-shaped structure.

9. The device of claim 1 wherein the helical coil assumes a secondary randomly-shaped structure.

10. The device of claim 9 wherein the  
5 randomly-shaped structure forms a substantially space-filling mass when released into the vessel.

11. The device of claim 1 wherein the helical coil assumes a secondary structure of continually  
10 changing helical diameters forming spirals.

12. The device of claim 11 wherein at least one spiral is dimensioned to span the cross-sectional area of the vessel to be occluded.

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FIG. 1

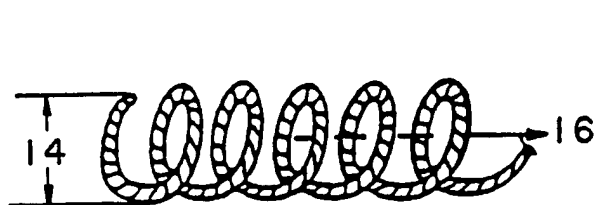
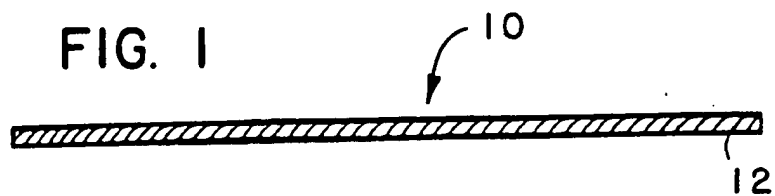


FIG. 2

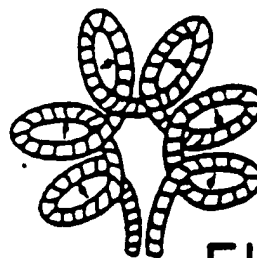


FIG. 3

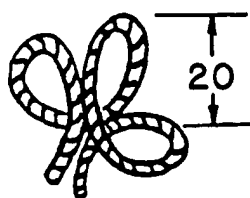


FIG. 4



FIG. 5



FIG. 6

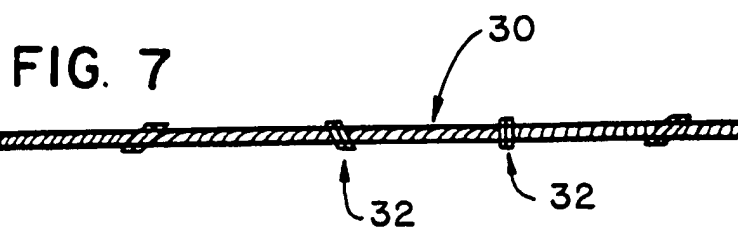


FIG. 7

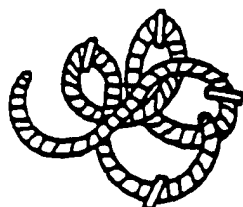


FIG. 8

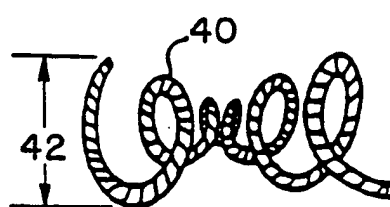


FIG. 9

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US93/00882

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61M 29/00

US CL :606/191

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/108,195,200; 128/898; 623/1,12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,994,069 (RITCHART ET AL) 19 FEBRUARY 1991 See entire document	1-12



Further documents are listed in the continuation of Box C.



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